Journal of Fluency Disorders 39 (2014) 12–24

Contents lists available at ScienceDirect

Journal of Fluency Disorders

Phonological encoding of young children who stutter

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ARTICLE INFO

Article history:
Received 17 September 2012
Received in revised form
25 September 2013
Accepted 25 October 2013
Available online 20 November 2013

Keywords:
Phonological encoding
Stuttering
Phonological awareness

ABSTRACT

Purpose: Several empirical studies suggest that children who stutter, when compared to typically fluent peers, demonstrate relatively subtle, yet robust differences in phonological encoding. Phonological encoding can be measured through the use of tasks that reflect the underlying mechanisms of phonological processing, such as phonological awareness. This study investigated the phonological encoding abilities of five- and six-year old children who stutter.

Methods: Young children who stutter were paired according to language ability, maternal education, and sex to their typically fluent peers. Participants completed multiple measures of phonological awareness abilities (i.e., sound matching, phoneme blending, elision), as well as measures of expressive and receptive vocabulary and articulation.

Results: Young children who stutter performed significantly less well than nonstuttering peers on tasks of elision and sound blending. No between-group differences were found in sound matching abilities or in any of the background language measures.

Conclusions: Results suggest that young children who stutter have subtle, yet robust, linguistic differences in certain aspects of phonological encoding that may contribute to an unstable language planning system in young children who stutter.

Educational Objectives: The reader will be able to: (a) describe how phonological awareness can inform our understanding of phonological encoding; (b) summarize the findings of previously published studies that examined some aspects of phonological awareness in children who do and do not stutter; and (c) compare the results of the current study with other investigations of phonological awareness skills in children who stutter and their typically fluent peers.

1. Introduction

1.1. Phonological awareness and phonological encoding

Some theorists posit that one contributing factor in the production of disfluencies is a difficulty with the underlying selection and preparation of the sounds that form the words in a speaker's message (Howell & Au-Yeung, 2002; Kolk & Postma, 1997; Perkins, Kent, & Curlee, 1991; Wingate, 1988). Although details of the psycholinguistic theories of stuttering vary, they all hypothesize that a delay or breakdown occurs when phonological words are constructed from individual phonemes, that is, during the process of phonological encoding (Howell & Au-Yeung, 2002; Kolk & Postma, 1997; Perkins et al., 1991; Wingate, 1988). The theoretical construct of phonological encoding has been conceptualized differently in

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http://dx.doi.org/10.1016/j.jfludis.2013.10.003

various models of typical language formation. Some models, such as the Gestural Linguistic Model (Browman & Goldstein, 1992, 1997; Saltzman & Munhall, 1989), suggest that the process of phonological encoding is closely related to speech motor production. Other models, such as WEAVER++ (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999; Roelofs, 2004), posit that phonological encoding is a process that occurs before the speech motor system is activated. Both of these models include a process of phonological encoding, but the execution of this process is envisioned in different ways. The impetus for this current line of research has its basis in psycholinguistic theories of stuttering, thus, this article uses the definition of phonological encoding as forwarded by WEAVER++ (Levelt et al., 1999; Roelofs, 2004). WEAVER++ defines phonological encoding as the process by which the phonological code (i.e., phonemes or syllables) of a word is retrieved and reassembled in an incremental, just-in-time manner to allow for efficient construction of phonological words.

The process of phonological encoding is one that is obscured from direct observation because it is deeply embedded in the process of language formulation (Coles, Smid, Scheffers, & Otten, 1995; Meyer, 1992) and must therefore be explored through alternate processes that reflect its incremental nature. One aspect of phonological encoding that can be observed is the process of *phonological awareness*, which is an individual's ability to identify, isolate, and manipulate various-sized segments of speech such as words, syllables, onsets/rimes, and individual phonemes. Phonological awareness skills begin to stabilize around age five, allowing for exploration of the phonological encoding abilities of young children who stutter as close to the onset of stuttering as possible once phonological awareness skills are established. Performance on phonological awareness tasks also parallel the processes that occur during phonological encoding, thus providing a valuable research tool in this empirical investigation of the phonological encoding skills of children who stutter.

1.2. Phonological awareness

Phonological awareness tasks are well understood and frequently used with preschool and school-age children (see reviews in Gillon, 2004; Sodoro, Allinder, & Rankin-Erickson, 2002; Troia, 1999). These abilities progress along a developmental continuum from less-to-more complex. Rhyming, sound matching, and phoneme blending abilities develop first, followed by later developing skills such as phoneme segmentation, elision and phoneme reversal (Adams, 1990; Gillon, 2004; Schuele & Boudreau 2008). *Rhyming* involves the determination of whether two words rhyme (e.g., "Which word rhymes with *cat*? *Cake, tin*, or *mat*?"). *Sound matching* tasks measure whether the child can identify individual phonemes and match the occurrence of those phonemes in sets of words (e.g., "Which word starts with the same sound as *pen*? *Pot, hat*, or *cane*?") *Phoneme blending* requires an individual to hear syllables or individual phonemes and blend them together to create a word (e.g., "What word do these sounds make? *pa–per*"). *Phoneme segmentation* measures an individual's ability to break apart the phonetic code of a word to identify and produce the constituent phonemes of that word (e.g., "Say the word *dog* one sound at a time. *d-o-g*"). *Elision* is the ability to remove a phonetic segment from a given word to create a brand new word. This requires the individual to not only break apart the phonemes of a given word, but also blend the remaining phonemes together to make a new word (e.g., "Say *plants* without saying/*l*/. *pants*"). Finally, *phoneme reversal* is a task that asks the individual to hear a word and then break apart the phonetic code so it can be reassembled in the reverse order, creating an entirely new word (e.g., "Say/*tif*/backwards. *feet*"). Five- and six-year old children are capable of completing tasks like rhyming, sound matching, and phoneme blending that use earlier-developing skills, while tasks like phoneme segmentation and phoneme reversal are typically established later (Gillon, 2004). Where a child falls along the developmental continuum should be considered when administering phonological awareness tasks to prevent inadvertent skewing of the outcomes due to developmentally inappropriate tasks.

Just as phonological awareness abilities emerge in a sequence from less-to-more complex, the stimuli used in each phonological awareness task can also be manipulated in terms of complexity. A less complex task such as phoneme blending can include stimuli that range from simple (e.g., "blend/*k-æ-t*/ → cat") to more complex (e.g., "blend/*i-m-*ɜ*-*ʤ*-*ɛ*-n-s-i*/ → emergency"). This is accomplished through the modification of the number of phonemes or syllables as well as the presence or absence of consonant clusters. Tasks containing more phonemes and syllables are more difficult to complete as there are more phonemes to identify, sort, or blend and must be held in working memory (Sevald, Dell, & Cole, 1995). The level of phonological complexity of the stimulus items will increase in difficulty with the presence of consonant clusters (Sasisekaran & Weber-Fox, 2012), as well as the inclusion of later developing phonemes (Moore, Tompkins, & Dollaghan, 2010; Storkel, 2001). Thus, both task and stimuli complexity should be considered when assessing phonological awareness abilities.

1.3. Phonological representations

Phonological representations in young preschool children are initially stored in holistic form, that is, "without detailed phonological segmentation" (Brooks & MacWhinney, 2000, p. 337). They then gradually undergo a developmental shift toward incremental representations that support just-in-time phonological encoding (Brooks & MacWhinney, 2000; Jusczyk, 1997; Metsala, 1999; Walley, 1993). The shift of phonological representations from holistic to incremental representations begins around age five and continues to refine until approximately age eleven (Brooks & MacWhinney, 2000). This growth occurs at roughly the same time that phonological awareness skills begin to develop and appears to parallel vocabulary growth as well (de Cara & Goswami, 2003; Jusczyk, 1993; Metsala & Walley, 1998; Nittrouer, 1996).

During the initial stages of development, a child's awareness is *implicit*: there is some level of understanding of sentences and words, but a child cannot isolate or identify these segments volitionally (Carroll, Snowling, Hulme, & Stevenson, 2003; Gombert, 1992). As children mature, phonological awareness expands to include not only large phonemic units, such as sentences and words, but also includes an awareness of more fine-grained phonemic representations, such as syllables and individual phonemes. Thus, phonological awareness in older children and adults is *explicit:* they are able to volitionally identify, segment, and manipulate words down to the smallest constituent sound (Anthony & Lonigan, 2004; Treiman & Zukowski, 1991, 1996). These evolving processes have particular relevance to the development of fluent speech. For example, Byrd, Conture, & Ohde (2007) demonstrated that five-year-old children who stutter appear to retain more immature holistic representations, while age-matched peers who do not stutter have shifted to more mature, and theoretically more efficient, incremental representations. If children who stutter maintain use of holistic representations longer than their non-stuttering peers, then the ability to segment phonological representations might be impaired as well.

A strong, positive correlation exists between expressive vocabulary and performance on phonological awareness tasks (Cooper, Roth, Speece, & Schatschneider, 2002). Therefore, performance on phonological awareness tasks can be influenced by general language and vocabulary ability. For example, if a child has strong expressive language skills, it is likely that the child also possesses strong phonological awareness skills. Conversely, a child with reduced expressive language abilities will possess reduced or depressed phonological awareness abilities. This indicates that there are potential moderating factors that may affect the outcome of a child's performance on phonological awareness tasks. Care must be taken to account for the potential contribution of language ability when exploring phonological awareness abilities and ensure that the participants in studies of phonological awareness are well matched on these abilities to lessen the possible contribution of the language abilities.

1.4. Stuttering and phonological awareness

Few studies have cited phonological awareness as a specific aim of investigation with individuals who stutter. Yet, closer examination of many recent studies of phonological encoding reveal that the tasks used could be characterized as phonological awareness tasks (e.g., rhyme monitoring, phoneme monitoring, segmentation). Studies have investigated phonological encoding using phonological awareness tasks with adults (Byrd, Vallely, Anderson, & Sussman, 2012; Sasisekaran & De Nil, 2006; Sasisekaran, de Nil, Smyth, & Johnson, 2006; Weber-Fox, Spencer, Spruill, & Smith 2004) and school-age children (Bajaj, Hodson, & Schommer-Aikins, 2004; Sasisekaran & Byrd, 2013; Sasisekaran, Brady, & Stein, 2013; Weber-Fox, Spruill, Spencer, & Smith, 2008), although not all of the studies have reported differences (Bajaj et al., 2004). Of these studies, the authors are aware of only one that has included some young children who stutter, along with some school-age children, as participants in their investigation of phonological awareness abilities (Bajaj et al., 2004). Studies with young children who stutter provide an interesting opportunity to allow measurement of abilities closer to the onset of stuttering, yet it is unknown which young children who stutter will persist into adulthood or will recover. The children who persist in stuttering may possess different abilities than those who develop into typically fluent speakers, which make direct comparison of studies with school-age and preschool children difficult to interpret. No prior study has exclusively investigated these abilities in young children who stutter, but we can gain some insight from those with school-age participants.

Bajaj et al. (2004) investigated phonological awareness in 46 children who stutter and their nonstuttering peers. Participants ranged in age from 5:10 to 8:10; thus, only a portion of the participants in this study could be considered preliterate children. The phonological awareness tasks included administration of *The Lindamood Auditory Conceptualization Test* (LAC; Lindamood & Lindamood, 1979), which requires phoneme identification and manipulation, as well as the Phoneme Reversal subtest of the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999). Bajaj et al. reported no significant between-group differences in performance on the three phonological awareness tasks. This study utilized three different phonological awareness tasks; however, when considering the developmental progression of phonological awareness, the tasks selected by the authors might not have been developmentally appropriate for all participants (Schuele & Boudreau, 2008). Phoneme reversal is considered a more developmentally advanced ability that requires the use of greater memory resources than are used when the sound matching task is conducted (Gillon, 2004; Schuele & Boudreau, 2008). The CTOPP manual indicates that the phoneme reversal task is recommended for children seven and older (Wagner et al., 1999), suggesting that the task may have been too difficult for approximately half the participants in Bajaj et al.'s study (i.e., children in kindergarten and first grade). Conversely, the sound matching task may have been too developmentally simple for the older children (McBride-Chang, Wagner, & Chang, 1997; Wagner et al., 1999). Without access to the original data, it is difficult to determine if these factors might have masked a potential difference. Bajaj et al. were careful to note that their study only examined a few components of phonological awareness and suggested that further exploration would be warranted to come to a full conclusion regarding the phonological awareness skills of children who stutter.

Sasisekaran and Byrd (2013) investigated nine school-age children who stutter, matched for chronological age and sex, to nine nonstuttering peers. The children ranged in age from 7 to 13. The participants completed phoneme monitoring and rhyme monitoring tasks in single syllable words and nonwords. The complexity level of the monosyllabic stimuli was manipulated by asking the participants to monitor for phonemes that were embedded in a consonant cluster, which is a developmentally harder task to complete. Receptive vocabulary, working memory, and phonemic awareness are all variables that are known to influence performance on phonological awareness tasks. Thus, participants were also administered the Peabody Picture Vocabulary Test – 4th Edition to measure receptive vocabulary, forward and backward digit span from

Weschler's Memory scale as a measure of short-term memory, and the LAC as a measure of phonemic awareness. No between-group differences were reported on these measures. Sasisekaran & Byrd reported that both groups of children took longer to identify the target phoneme if it was embedded within a consonant cluster (increased complexity), but the authors reported that children who stutter required a longer period of time than their nonstuttering counterparts to determine if the phoneme was present. Although no significant between-group differences in response times were reported for either task, a re-examination of the data by the authors revealed that the older participants performed at ceiling on these tasks, while the younger children who stutter took longer to respond than their typically fluent peers. Sasisekaran & Byrd interpreted their findings as an indication that the phonological encoding of children who stutter is not frankly disordered but that subtle differences were beginning to emerge as the task complexity increased.

Sasisekaran et al. (2013) conducted a similar phoneme monitoring study with nine school-age children who stutter (age 10 to 14 years), matched on age and sex, to nine nonstuttering children. Expressive and receptive vocabulary, working memory, articulation, and phonemic awareness were all measured, in addition to the investigation of phoneme monitoring in two syllable words. Contrary to the findings reported by Sasisekaran and Byrd (2013), there were significant between-group differences in the phoneme monitoring task, and the measure of phonetic awareness, the LAC. The significant difference reported for the phoneme monitoring may have been due to the increase in stimuli complexity through the use of two-syllable words which increases the level of difficulty of the task. Alternatively, the reduced performance of the children who stutter in the phoneme monitoring task may have been secondary to differences in phonemic awareness abilities as indicated by the LAC, or a combination of both. Continued research in this area, with particular attention paid to the complexity level of stimuli and tasks, is therefore warranted if researchers are to better understand whether phonological awareness may play a role in the production of disfluencies and the development of stuttering.

The aim of the present study was to compare the phonological encoding abilities of 5 and 6 year-old children who stutter and their typically fluent peers by measuring their performance on a diverse range of developmentally appropriate phonological awareness tasks. The theoretical implication of phonological encoding, combined with the initial evidence that phonological awareness is different in school age children who stutter, suggests that further investigation into the phonological awareness abilities of children who stutter may contribute to our understanding of the role phonological encoding may play in the development of stuttering.

2. Methods

2.1. Participants

Participants were 10 monolingual, Standard American English speaking children who stutter (4 females and 6 males, mean age = 66.9 months; SD = 7.2; range = 60–83 months) matched on general language ability, sex, and maternal education (as a measure of socioeconomic status) to 10 children who do not stutter (4 females and 6 males, mean age = 69.44 months; SD = 6.4; range = 60–78 months). General language ability, sex, and socioeconomic status are variables that are known to be strongly correlated with phonological awareness skills (Cooper, Roth, Speece, & Schatschneider, 2002). Participants were carefully paired according to these factors in an effort to reduce any possible moderating effect. These relationships are discussed in more detail in Sections 2.2.2 and 2.2.3. Informed consent was obtained for all 20 participants and Institutional Review Board approval was granted from the University of Pittsburgh. Participants were recruited through Children's Hospital of Pittsburgh and through local advertisements. A total of 28 children were recruited for the study (15 children who stutter and 13 typically fluent children), but due to the strong influence language abilities and socioeconomic status have on phonological awareness skills, only those 20 children who could be matched closely on the matching factors were included in the study. Five children who stutter (three male, two female) and three nonstuttering children (one male, two female) were excluded from data analysis because they did not meet the matching criteria for general language abilities and sex. Participants may have previously received speech therapy or they may have been currently enrolled in speech therapy for stuttering at the time of the study. There is no evidence that previous or concurrent speech therapy for stuttering is associated with a child's ability to complete phonological awareness tasks (Byrd, Logan, & Gillam, 2012; Byrd, Vallely, et al., 2012; Logan, Byrd, Mazzocchi, & Gillam, 2011). All participants passed a pure-tone audiometric screening in the year prior to participation in the current study, as confirmed by parental report. Aside from stuttering exhibited by the children who stutter, all subjects had no known hearing, language, or neurological difficulties based on parental report and a broad language screening evaluation discussed in detail below.

2.2. Inclusion and matching criteria

2.2.1. Speech fluency

A spontaneous speech sample of at least 500 syllables was obtained to determine the frequency and nature of speech disfluencies for children in both groups. The *Stuttering Severity Instrument-3* (SSI-3; Riley, 1994) was used to assign a severity rating to both groups of participants. Six children who stutter were rated as mild and four were rated as moderate-to-severe. Stuttering frequency data (i.e., percent syllables stuttered) was collected to determine a participant's group placement. Participants were assigned to the group of children who stutter if: (a) they received an overall score of at least 11 (mild) on the SSI-3, (b) they exhibited three or more stutter-like disfluencies (single-syllable word repetitions, part-word repetitions, sound prolongations, or blocks; e.g., Yairi & Ambrose, 1992) per 100 words of conversational speech (based on a speech sample as described below); and (c) at least one adult familiar with the child has expressed concerns about stuttering (e.g., Yaruss & Conture, 1996). Participants were placed in the group of children who do not stutter if: (a) they received a total overall score of 10 (less than mild) or below on the SSI-3, (b) exhibited less than three stutter-like disfluencies per 100 words of conversational speech (e.g., Yairi & Ambrose, 1992), and (c) no one in the child's environment expressed concerns about stuttering. Participants were then matched according to sex, general language skills, and maternal education level to support comparisons between the groups of children who stutter and children who do not stutter as described in the following sections.

2.2.2. General language abilities

Language skills account for a significant variance in the phonological awareness skills of children (Cooper, Roth, Speece, & Schatschneider, 2002). Children with strong language abilities typically perform well on phonological awareness tasks, while those with poorer language abilities tend to perform more poorly on tests of phonological awareness. This potential contributing factor was controlled in this study by matching children who stutter and their typically fluent peers in terms of general language abilities. All participants were administered the "Quick Test" version of the *Clinical Evaluation of Language Fundamentals–Preschool* (CELF-P; Wiig, Secord, & Semel, 1992) which includes the *Linguistic Concepts* subtest (CELF-P LC) and the *Recalling Sentences in Context* subtest (CELF-P RS). The CELF-P manual states that these two subtests could be used as a screener unless the child received a standard score below seven on either one of the subtests, then that child should be administered the full battery of six subtests. Participants were excluded from this study if they scored below the cut-off criteria on either subtest. This was to ensure that the participants' overall language abilities were within typical limits without increasing the risk of fatigue by administering a full test battery. Standard scores for each subtest were then averaged together to form a composite *Language Matching Score* and were used to match pairs of participants on general language ability, plus or minus one standard point.

2.2.3. Socioeconomic status

Socioeconomic status (SES), including maternal education levels, may impact the language experiences a young child encounters (see review in Dollaghan et al., 1999). In addition, significant differences in phonological awareness abilities are evident between social classes, where children with higher SES typically perform better on phonological awareness tasks than their peers from lower SES (Bowey, 1995; Burgess, 2002; McDowell, Lonigan, & Goldstein, 2007; Nittrouer & Burton, 2005). Assessing maternal education level is believed to be a less divisive and intrusive measure of SES than family income (Hauser, 1994). Therefore, participants were matched on maternal education level. Maternal education was characterized as (a) less than high school graduate, (b) high school graduate, or (c) college graduate (Dollaghan et al., 1999). All participants in both the stuttering and non-stuttering groups had mothers who graduated from college ($N = 20$) and all possessed advanced degrees. The fact that all of the participants were categorized as having a high level of maternal education indicates that these groups were equally matched and also indicates that both groups of children had the greatest likelihood to perform well on phonological processing tasks, although it may limit generalization of the findings to the larger population.

2.3. Data collection tasks and procedures

2.3.1. Speech and language development

A battery of standardized tests was administered to determine each child's language abilities. These measures were collected in addition to the language matching variables described in Section 2.1. The battery included measures of: (a) receptive vocabulary ability (*Peabody Picture Vocabulary Test–III* [PPVT-III], Dunn & Dunn, 1997), (b) expressive vocabulary ability (*Expressive Vocabulary Test* [EVT], Williams, 1997), and (c) speech sound abilities (*Goldman-Fristoe Test of Articulation–2* [GFTA-2], Goldman & Fristoe, 2000). Receptive and expressive vocabulary skills were of interest for this study because some researchers believe that vocabulary development is a precursor to phonological awareness (Bowey, 1996; Metsala & Walley, 1998; Walley, Metsala, & Garlock, 2003). Specifically, Walley et al. hypothesized that as more vocabulary words are obtained, the lexicon undergoes a period of reconstruction wherein the representations become more incremental to accommodate the larger number of vocabulary words to be stored. This increased segmentation is believed to aid in the development of phonological awareness skills in young children. Therefore, the PPVT-III and EVT were administered to determine the children's receptive and expressive vocabulary skills, respectively. Finally, Cooper and colleagues (2002) suggested that speech sound ability may also impact phonological awareness. Therefore, the GFTA-2 was used to determine the participants' speech sound ability. Pair-wise comparisons of the data from these measures were made to provide additional information on the participants' overall language abilities to ensure that any difference found in phonological awareness abilities were not due to language differences.

2.3.2. Phonological awareness

The dependent variable in this study was the participants' phonological awareness abilities. These were assessed using phonological awareness subtests of the *Comprehensive Test of Phonological Processing: Ages 5–6* (CTOPP; Wagner, Torgesen, & Rashotte, 1999); a standardized test of phonological processing. The *Phonological Awareness Composite Score* represents a combination of the standard scores of three subtests: *Sound Matching* subtest, *Blending Words* subtest, and *Elision* subtest.

The *Sound Matching* subtest required the participants to listen to a target word followed by a series of words and determine which words shared an initial or final phoneme with a target word. The Sound Matching subtest of the CTOPP is only used in the Ages 5 and 6 version of the test because it is one of the earlier developing phonological awareness abilities. This subtest asked the child, "Which word starts with the/s/sound like *sock*? *Sun* or *bear*?" The *Blending Words* subtest is more developmentally complex than the Sound Matching subtest and required the participant to form real words by synthesizing sounds together (e.g., "What word do these sounds make? *Can–dy*"). Test item difficulty for the Blending Words subtest ranged from items that are easy for five year olds (e.g., blending/*num - bɚ*/into the word/*numbɚ*/*number*) to items that are difficult for adults (e.g., blending/*m-æ-θ-ə-m-æ-t-I-k-s*/into the word/*mæθəmætIks*/*mathematics*). Finally, the most complex phonological awareness task appropriate for 5- and 6-year old children was the *Elision* subtest, which required the participant to break apart spoken words to create a new word by removing specific phonological segments (e.g., "Say *airplane* without saying *air*," with the correct response being *plane;* "Say *cup* without saying/*k*/," with the correct answer being *up*). The difficulty level of the stimulus items in the Elision subtest included stimuli that were easy for five year olds (e.g., "Say *popcorn* without saying *corn*," with the correct answer being *pop*) to increasingly more difficult stimuli for adults (e.g., "Say *fixed* without saying/*k*/," with the correct answer being *fist*). These three subtests together form the *Phonological Awareness Composite Score* measuring a child's "awareness of and access to the phonological structure of oral language" (Wagner et al., 1999, p. 46). The stimuli in each subtest were designed to begin at the most simple level and then increase in complexity as the task progressed, thereby avoiding floor or ceiling effects. The phonological awareness subtests of the CTOPP have been reported as a reliable and valid tool for measuring phonological awareness. Reliability coefficients for the CTOPP subtests and composite score for ages 5 and 6 are as follows: Sound Matching subtest = .93; Blending Words subtest = .89; and Elision subtest = .91; Phonological Awareness Composite = .96 (Wagner et al., 1999).

2.4. Testing procedures

Testing (screening and primary data collection) occurred in a single session that lasted between 90 and 120 min. The participants were seated with the first author at a table appropriately sized for a child during data collection. The standardized tests were administered in the following order by the same certified speech-language pathologist (the first author): the CELF-P LC and the CELF-P RS (to determine eligibility and participant matching), the PPVT-III, the GFTA-2, the EVT, and finally the CTOPP. Once the child's eligibility was determined with the completion of the CELF-P subtests to determine the language matching score, the tasks were then presented in order according to the increasing level of verbal and linguistic demand required. For example, the PPVT-III requires the child simply to point to the picture that matches the stimulus item given. The GFTA-2 requires the child to name simple pictures to determine articulation ability. The EVT requires the child to provide a synonym for the picture presented, and the CTOPP requires the child to match phonemes, blend syllables, and perform rapid naming tasks. Thus, the tasks were arranged from least linguistically and cognitively demanding to more linguistically and cognitively demanding. Short breaks with age-appropriate toys were taken between measures to minimize the impact of fatigue. All data collection sessions were audio/video-recorded on a Panasonic AG-456 video camera to allow for analysis of inter-judge and intra-judge reliability.

2.5. Reliability measurement

All data collection was conducted by the same certified speech-language pathologist (first author) to maintain a level of consistency in data collection. Videotapes from 20% of the study participants (i.e., four participants total; two from each group) were randomly selected and reviewed independently by a second, certified speech-language pathologist trained in the analysis of disfluent speech to determine inter-judge reliability for percent syllables stuttered, EVT, PPVT-III, GFTA-2, and CTOPP scoring. Percent syllables stuttered from the spontaneous speech sample was used to determine group membership (i.e., children who stutter verses typically fluent children). The non-parametric Spearman's rho was used to determine the inter-rater reliability and was found to be highly reliable between raters ($r_s = .919$; $p < .05$). EVT and PPVT-III were in 100% agreement between the two judges, while the GFTA-2 was found to be 98% in agreement with the first author. Agreement for the various subtests of the CTOPP ranged from 94% to 100% accuracy for inter-judge agreement. Intra-judge reliability was also determined through review of the data for 20% of the participants (i.e., four participants total; two from each group). The videos were again randomly selected for the first author to view and rescore. The results of the first and second scoring were then compared and determined that all judgments were found to be between 97% and 100% in agreement.

2.6. Data analysis

The participants in this study were paired to control for potentially contributing factors, thus, the nonparametric Wilcoxon Signed-Ranks Test was selected to compare the between-group data because it is appropriate for use with paired samples and relatively small sample sizes. The Wilcoxon Signed-Ranks Test is also robust to violations of normality. Experiment-wise alpha was set at .05.

Table 1
Demographic information and background measures. Goldman-Fristoe Test of Articulation-2 (GFTA-2), Expressive Vocabulary Test (EVT); Peabody Picture Vocabulary Test-III (PPVT-III); Stuttering Severity Instrument-III (SSI-3).

Pair number	Fluency status	Age	Language matching score	GFTA-2	EVT	PPVT	Sex	Maternal education level	SSI-3
Pair 1	CWS	6;11	10.0	99	96	99	Male	Graduate degree	Moderate-Severe
	CWNS	5;11	9.5	89	97	107	Male		
Pair 2	CWS	5;6	10.5	89	85	106	Male	Graduate degree	Mild
	CWNS	5;0	10.5	103	92	112	Male		
Pair 3	CWS	5;0	11.0	111	111	117	Male	Graduate degree	Mild
	CWNS	5;6	11.0	103	105	110	Male		
Pair 4	CWS	5;4	11.5	113	112	113	Male	Graduate degree	Mild
	CWNS	6;4	11.5	109	110	101	Male		
Pair 5	CWS	6;0	12.0	91	91	97	Male	Graduate degree	Moderate-Severe
	CWNS	5;5	12.0	113	112	113	Male		
Pair 6	CWS	5;6	13.5	106	115	143	Male	Graduate degree	Mild
	CWNS	5;3	13.5	114	125	131	Male		
Pair 7	CWS	5;11	9.5	110	103	109	Female	Graduate degree	Mild
	CWNS	5;6	10.0	100	85	104	Female		
Pair 8	CWS	5;0	12.0	116	107	123	Female	Graduate degree	Moderate-Severe
	CWNS	6;6	11.0	107	111	110	Female		
Pair 9	CWS	5;1	12.5	106	112	118	Female	Graduate degree	Mild
	CWNS	5;11	13.5	111	122	115	Female		
Pair 10	CWS	5;6	8.5	112	100	101	Female	Graduate degree	Moderate-Severe
	CWNS	6;6	9.5	92	97	99	Female		

3. Results

The Wilcoxon Signed-Ranks revealed no significant differences between groups for the EVT ($Z = -.969$; $p = .333$; $d = -.22$), the PPVT-III ($Z = -1.275$; $p = .202$; $d = .22$), and the GFTA-2 ($Z = -.204$; $p = .838$; $d = 14$). Table 1 summarizes the participants' demographic information, including chronological age, Language Matching Score, fluency status, sex, maternal education level, stuttering severity, as well as the additional background measures of vocabulary and articulation (GFTA-2, EVT, PPVT-III).

Paired data for the Phonological Awareness Composite score, Sound Matching, Blending Words, and Elision subtests are detailed in Table 2. Analysis of the paired samples with the Wilcoxon revealed a significant between-group difference for the Phonological Awareness Composite score, with a large effect size ($Z = -2.448$; $p = .014$; $d = -1.4$). According to Cohen (1977), d scores greater than .80 indicate large effect sizes. Analysis of the constituent subtests revealed no significant difference for the Sound Matching subtest ($Z = -1.791$; $p = .073$; $d = -0.9$), indicating that the paired groups performed similarly on this subtest. Children who stutter scored significantly lower than children who did not stutter on the Elision subtest ($Z = -2.200$; $p = .028$; $d = -1.0$) and the Blending Words subtest ($Z = -2.375$; $p = .018$; $d = .96$).

Large effect sizes were demonstrated for the Blending Words, Sound Matching, and Elision subtests. Although children who stutter performed significantly less well than their non-stuttering peers on two of the three phonological awareness

Table 2
Individual data for young children who stutter (CWS) and young children who do not stutter (CWNS).

Pair number	Fluency status	Composite score	Elision	Blending words	Sound matching
Pair 1	CWS	100	9	11	10
	CWNS	109	12	11	11
Pair 2	CWS	94	8	8	11
	CWNS	104	10	11	11
Pair 3	CWS	91	8	8	10
	CWNS	111	9	12	14
Pair 4	CWS	104	9	11	12
	CWNS	109	10	11	13
Pair 5	CWS	91	8	7	10
	CWNS	115	13	12	12
Pair 6	CWS	100	9	9	12
	CWNS	106	10	12	11
Pair 7	CWS	117	13	12	13
	CWNS	111	12	12	11
Pair 8	CWS	89	10	8	7
	CWNS	102	10	10	11
Pair 9	CWS	96	9	8	11
	CWNS	130	17	12	15
Pair 10	CWS	91	8	9	9
	CWNS	94	8	9	10

measures, none of the participants scored more than one standard deviation below the mean on the standardized measures (composite score: $M = 100$, SD = 15; subtests: $M = 10$, SD = 3). The average score for children who stutter on the Phonological Awareness Composite score was 97.3 (range: 89–117), while typically fluent children scored an average of 109.1 (range: 94–130). Still, significant differences were present despite the fact that children who stutter did not demonstrate significantly impaired phonological awareness skills.

4. Discussion

Some researchers argue that a difference at the level of phonological encoding will result in the interruption of fluent speech (Howell & Au-Yeung, 2002; Kolk & Postma, 1997; Perkins et al., 1991; Wingate, 1988). Unfortunately, it is difficult to isolate and measure the process of phonological encoding directly because it is deeply embedded within the multiple processes involved in speech formulation. The ability to identify, isolate, and manipulate individual phonemes is called phonological awareness and can be measured using a number of tasks such as phoneme blending, phoneme segmentation, and elision. In fact, the phonological awareness task of blending could be thought of as very much like the process of phonological encoding itself, where individual phonemes are retrieved and blended together to form phonological words, albeit in a much faster and more implicit way. Thus, investigation into the phonological awareness abilities of children who stutter can provide an alternative to measuring phonological encoding and contribute to a greater understanding of phonological encoding in children who stutter.

The present study revealed two main results. First, young children who stutter scored significantly lower than the young children who do not stutter on two of the three phonological awareness tasks. Although children who stutter performed less well than matched peers on all phonological awareness measures, none of the children scored below one standard deviation from the mean on the phonological awareness measures indicating a robust, yet subtle difference was present. Second, between-group differences in phonological awareness were present even though there were no between-group differences in variables that are known to influence performance on phonological awareness tasks (i.e., articulation, receptive or expressive vocabulary knowledge).

4.1. Finding #1: Reduced phonological awareness abilities of young children who stutter

The current investigation reported significant between-group differences in two of the later developing phonological awareness tasks. No prior studies have investigated phonological awareness with only preschool participants, rendering direct comparison of the results difficult. Still, the results from the present study support Byrd et al.'s (2007) investigation of the holistic and segmental representations of preschool children who stutter. Byrd and colleagues reported that preschool children who stutter persisted in the maintenance of holistic phonological representations after their typically fluent peers have transitioned to more mature, incremental phonological representations. If preschool children who stutter store phonological representations in a more holistic manner, then completion of these tasks that require explicit knowledge and manipulation of the individual phonemes of words may be hindered and lead to differences in phonological encoding.

Young children who stutter scored significantly below typically fluent children on measures of phonological awareness in the current study, yet all of the scores for both groups fell within one standard deviation of the mean. The differences between groups were expected to be subtle (Hakim & Bernstein Ratner, 2004; Hall, Wagovich, & Bernstein Ratner, 2007; Newman & Bernstein Ratner, 2007) and support the results that suggest that young children who stutter possess "depressed" or "subclinical" differences in phonological awareness abilities. This result is also in line with findings by Sasisekaran et al. (2013) who reported that school-age children who stutter took significantly longer to monitor for phonemes in bisyllabic words than their typically fluent peers, but did not report any differences between groups in accuracy. These significant differences in timing, but not accuracy, could be interpreted as further evidence of subtle differences in phonological encoding, but not enough difference to impact accuracy levels. The between-group differences in phonological awareness reported in the current study are also in agreement with the findings reported by Weber-Fox et al. (2008) that indicated school-age children who stutter demonstrated different, or atypical, phonological awareness skills as compared to nonstuttering peers. The authors concluded that the phonological processing abilities are poorer for children who stutter as compared to their typically fluent peers but that these differences are subtle. The studies by Sasisekaran et al. and Weber-Fox et al. investigated the abilities of literate school-age children who stutter, while the current study investigated pre-literate, 5 and 6 year old children. Still, all three studies support the notion that robust differences are present, but are not necessarily indicative of an obvious phonological encoding disorder.

4.2. Finding #2: Descriptive measures

Descriptive data on the participants were collected to determine if differences were present in basic abilities that are known to influence performance on phonological processing tasks (e.g., articulation ability, expressive and receptive vocabulary skills). These data were collected in addition to the general language score that was used as a participant matching variable. No significant between-group differences were present for any of the speech and language measures listed above. Participants were closely matched and both groups performed within normal limits across all speech and language measures, yet young children who stutter still performed significantly less well than their typically fluent peers on two out of the three phonological awareness measures. The relative equality of the background measures for the groups suggests that differences found in the dependent variables are likely reflective of phonological processing ability and not the result of potentially influential or confounding factors. Although statistical analysis of potentially moderating effects was not possible in the current study due to a relatively small *n* (Fairchild & MacKinnon, 2009), future studies should consider these factors.

4.3. Potential contributing factors

Phonological awareness is not a process that occurs in isolation. Many researchers recognize that the use of additional skills, such as auditory perception, phonological memory, and attention processes may contribute to the successful completion of phonological awareness tasks (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe 2003; Dickinson & Snow, 1987; McBride-Chang, 1995; Wagner, Torgesen, & Rashotte, 1994). Sound matching requires that the initial or final phoneme of a word be identified and held in memory while hearing other words and searching for the same phoneme. The Blending Words task requires individual phonemes must be perceived and held in memory while blending the phonemes together to create a real word. Elision, on the other hand, requires that a phonological word is held in memory while a single phoneme is identified and removed from the word, then requiring that the remaining phonemes are then blended together to create a new word. The use of tasks that require both phonological awareness and phonological memory skills may have resulted in an increased cognitive load that contributed to the variance.

4.3.1. Phonological memory

Adequate phonological memory is necessary to complete phonological awareness tasks, and nonword repetition is a task that is frequently used as a measure of phonological memory. A number of studies have reported that children who stutter have a reduced ability to maintain phonological code in memory (Anderson, Wagovich, & Hall, 2006; Hakim & Bernstein Ratner, 2004; Oyoun, El Dessouky, Shohdi, & Fawzy, 2010). A companion study by Pelczarski and Yaruss (in preparation) also investigated the phonological memory ability of children who stutter. Nonword repetition and serial recall tasks were administered and a significant difference on the nonword repetition subtest, but not the serial recall task, was revealed. Weber-Fox et al. (2008) also administered a nonword repetition task (Nonword Repetition Task, NRT; Dollaghan & Campbell, 1998) to school-age children as a way to measure phonological memory. Unlike the findings of Pelczarski and Yaruss, no differences between stuttering and nonstuttering children were reported. These seemingly conflicting findings are likely due to the age differences in the two studies. Pelczarski and Yaruss investigated 5 and 6 year old children, while Weber-Fox et al. investigated school-age children who stutter. The NRT was designed for use with young children and used nonwords with reduced phonological complexity. Weber-Fox and colleagues acknowledged that a test that contained more phonologically complex words might have revealed some between-group differences, but that could not be determined from the available data. These findings suggest that phonological memory may also be different in children who stutter. Empirical evidence suggests that phonological awareness and phonological memory interact more in younger children and eventually separate into distinct processing skill-sets in older children and adults (Cornwall, 1992; Gathercole, Willis & Baddeley, 1991; Savage et al., 2005). Still, phonological awareness tasks used in the current study have been shown to measure abilities that are distinct from those measured by phonological memory (McBride-Chang, 1995).

4.3.2. Regulation of attention

Many researchers have reported that children who stutter can have difficulty with attention regulation (e.g. Bosshardt, 2002, 2006; Conture, Walden, Arnold, Graham, Hartfield, & Karrass, 2006; Eggers, de Nil, & van den Bergh, 2012; Felsenfeld, van Beijsterveldt, & Boomsma, 2010; Oomen & Postma, 2001; Schwenk, Conture, & Walden, 2007). An alternative account for the significant differences reported in the current study may be that these differences are due to cognitive load and attentional resources. As the task complexity increased with word length and phonological complexity, the cognitive load required to complete the task increased as well. This increase in cognitive load could certainly contribute to the breakdown of fluent speech. Weber-Fox et al. (2008) also interpreted their results of a rhyming task in light of attention processes. They argued that the more challenging tasks required a heavier cognitive load which resulted in the reported differences. Felsenfeld et al. (2010) investigated parental reports of children ages 5 and 7 from a large population sample of twin children to examine the relationship between fluency status and attentional difficulties. The authors reported that such a relationship did exist, but indicated that the majority of the children who stutter in this study would not be classified as possessing an attentional disorder. Rather, many of these children presented with subclinical attentional difficulties. Subtle differences in attentional abilities may have contributed to differences in phonological awareness.

4.4. Considerations for future investigations

An increasing number of studies have investigated the phonological encoding abilities of children and adults who stutter (Bajaj et al., 2004; Byrd, Vallely, et al., 2012; Sasisekaran & De Nil, 2006; Sasisekaran et al., 2006; Sasisekaran & Byrd, 2013; Sasisekaran et al., 2013; Weber-Fox et al., 2004; Weber-Fox et al., 2008), but inconsistent results have been reported. Although few studies have specifically examined phonological awareness, many have included tasks that can be considered to be phonological awareness tasks (e.g., phoneme monitoring, blending, and rhyming). A great deal is known about the variables that influence performance on phonological awareness tasks (i.e., general language, vocabulary ability, and socio-economic status). Much can be learned from this literature about variables that covary with phonological awareness. Learning these variables and applying them to future studies of phonological awareness/phonological encoding will help improve the consistency of the outcomes.

4.4.1. Matching variables

A variable that is strongly correlated with phonological awareness is general language ability. It is possible for participants with the same chronological age to possess a range of language abilities that are still considered to be within typical limits. Matching participants on all of these factors may help future studies to reveal more of these robust, yet subtle, differences. Another variable that influences performance on phonological awareness tasks is SES. If participants are not matched on this variable, it may influence the outcome of the studies due to the strong, positive correlations that exist between SES and phonological awareness. One limitation of the current study is the high SES background of the participants. All of the participant's mothers had earned an advanced college degree (which equates to a higher SES). Although the groups were evenly balanced in this regard, it does limit the generalizability of this study to individuals from low SES backgrounds. Future studies should investigate how varying SES backgrounds may influence between-group performance.

4.4.2. Task and stimuli complexity

The "sub-clinical" nature of these differences in phonological encoding requires that attention be paid to task and stimuli selection. Studies should be designed with tasks and stimuli that are sensitive enough to reveal the subtle differences in phonological encoding abilities that children who stutter appear to be demonstrating. Many researchers have reported limited or emerging differences in their investigations, yet many of these studies were not specifically designed to investigate phonological awareness and as such, may not have identified the tasks as ones that are frequently used to measure phonological awareness.

The current study reported robust between-group differences on the Blending Words and Elision subtests but not on the Sound Matching subtest, which may have been due to task complexity. Stahl and Murray (1994) reported that typically developing kindergarteners performed at or near ceiling on a similar type of sound matching task. In the current study, all but one participant from both groups performed at or above the mean for the Sound Matching subtest, indicating perhaps that the task was too easy to detect the subtle differences in phonological awareness that children who stutter possess. Weber-Fox and colleagues (2008) reported significant differences were only present between school-age children who stutter and their typically fluent peers on the most challenging of the rhyming stimuli. Only stimuli that were sufficiently complex revealed subtle differences that were not evident with the less complex (i.e., less challenging) rhyming stimuli. Sasisekaran and Byrd (2013) investigated the phoneme and rhyme monitoring abilities of school-age children who stutter. They did not report significant between-group differences, but significant differences emerged when they analyzed the data from only the younger participants. Sasisekaran and Byrd (2013) reported no significant differences were present when investigating the phoneme and rhyme monitoring abilities of school-age children who stutter. They reported that the older children in the study performed at ceiling, perhaps because the task was not complex enough for the older children (only single-syllable stimuli were used). This finding prompted them to analyze the only data from the younger children, which revealed a significant between-group difference. Sasisekaran et al. (2013) investigated a similar phoneme monitoring task using two-syllable stimuli and reported significant between-group differences. Analysis of task and stimuli choice may account for the limited and inconsistent findings. When these tasks are viewed in different light, potential confounding variables can be highlighted to help reveal these subtle differences in phonological encoding.

5. Conclusion

A number of theories of stuttering have suggested that one potential cause for disfluencies is a difficulty with the underlying selection and preparation of the sounds that form the words in a speaker's message (Howell & Au-Yeung, 2002; Karniol, 1995; Perkins, Kent, & Curlee, 1991; Postma & Kolk, 1993; Wingate, 1988). The differences in phonological awareness and phonological encoding reported here are robust, yet subtle, indicating that when combined with other factors, such as motoric, linguistic, or cognitive abilities the phonological processing systems of children who stutter may become overwhelmed and result in stuttered speech. In addition to contributing to the existing phonological awareness research, the results from the present study also support current psycholinguistic theories that argue that some aspect of phonological encoding is delayed or disrupted in people who stutter.

CONTINUING EDUCATION

QUESTIONS

(1) Which statement is incorrect regarding phonological awareness?
   a. Phonological awareness skills begin to develop parallel to vocabulary growth;
   b. Phonological awareness tends to stabilize enough to be reliably measured around the age of five;

c. Phonological awareness is a process that occurs in isolation;
d. Rhyming tasks are considered a task of phonological awareness;
e. All of the above statements about phonological awareness are correct.

(2) Results from the present study indicate which statement about phonological processing abilities in young children who stutter?
a. Young children who stutter possess a large deficit in phonological awareness abilities as demonstrated in their difficulty segmenting, blending, and manipulating phonological code;
b. Young children who stutter do not possess any difficulties with phonological processing;
c. Phonological processing ability does not have any contribution to whether or not a person stutters;
d. Significant differences are noted in the phonological processing abilities between young children who stutter and young children who do not stutter but these differences do not necessary indicate a phonological awareness disorder;
e. None of the above.

(3) Which of the following is an accurate statement regarding the results of the current study?
a. There was a small effect size revealed for the Phonological Awareness Composite score;
b. There were no significant between-group differences for the Phonological Awareness Composite Score;
c. Young children who stutter scored at an equivalent level as children who do not stutter on the Elision subtest;
d. Young children who stutter performed similarly to children who do not stutter on the Sound Matching subtest;
e. Preschool children who stutter performed similarly to preschool children who do not stutter on the Blending Words subtest.

(4) Which statement is false regarding the initial stages of phonological awareness development?
a. Phonological awareness is believed to stabilize enough to be reliably measured at approximately age three;
b. Phonological representations in young children are initially stored "without detailed phonological segmentation";
c. Phonological representations shift from being stored in holistic form to incremental depictions at age five;
d. Vocabulary growth develops around the same time phonological awareness skills emerge;
e. In the early stages of development, a child's awareness skills are implicit; a child is able to understand some sentences and words but cannot accurately isolate or identify these segments.

(5) Which of the following provides an accurate example of a blending task?
a. Instruct client to combine phonemes together to create one word;
b. Instruct client to match a picture of an object with a presented target word;
c. Instruct client to break apart a target word into individual phonemes;
d. Instruct client to break apart a target word and produce the word in reverse order of the phonemes;
e. Instruct the client to produce the cluster found in the target word.

Financial Disclosures

None of the authors of the paper "A Preliminary Examination of Phonological Encoding Abilities in Young Children who Stutter" by Pelczarski, K.M. & Yaruss, J.S. reported any reported any relevant financial relationships to be disclosed.

Non-Financial Disclosures

None of the authors of the paper "A Preliminary Examination of Phonological Encoding Abilities in Young Children who Stutter" by Pelczarski, K.M. & Yaruss, J.S. reported any relevant non-financial relationships to be disclosed.

Acknowledgments

We would like to thank the children who participated in this study and their families for their time and effort. A portion of this study was presented at the American Speech, Language, and Hearing Association conference.

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